#P45A_120 MW
Thompson 115 kV or Lackawanna – East Carbondale 69 kV
Generation Interconnection

This analysis was completed to assess the reliability impact for a new 120 MW generator interconnecting to the PJM system as a 24 MW Capacity Resource and a 120 MW Energy Resource.

Option #1 – Thompson 115 kV Interconnection

Network Impacts (Option #1)

The **P45A project was studied as an injection of 120 MW (energy), 24 MW (capacity) into the Tiffany – Thompson 115 kV line.** Project P45 was evaluated for compliance with reliability criteria for summer peak conditions in 2010. Potential Network Impacts were as follows:

Generator Deliverability
At P45A position in the Queue, with all other previous nearby in-service and queued generators at their maximum requested (20% for wind) Capacity output, the Thompson 115-34.5 kV transformer is contingency overloaded at 102.2 % of emergency rating for the loss of the Tiffany-P45 115 kV line. Queue P45A contributes 0.5 MW to the contingency overloading. The Thompson 115-34.5 kV transformer emergency rating is 23.4 MVA.

Multiple Facility Contingency
No problems identified.

Short Circuit
Under study – Results will be provided for the Impact Study.

New System Reinforcements
The estimated cost to upgrade the Thompson 115-34.5 kV transformer is $1.1 million. The upgrade is a replacement of existing 20 MVA transformer rated at 21.8 MVA normal / 23.4 MVA emergency with a new 30 MVA transformer rated approximately 34 MVA summer normal / 40 MVA summer emergency. It is estimated that this upgrade will take approximately 2 years to complete.

Contribution to Previously Identified Overloads
None

Contribution to Previously Identified System Reinforcements
None

Potential Congestion Issues (Option #1)

The following analysis has been performed to inform the Interconnection Customer (Queue P45A) of potential congestion issues (operational restrictions) that may occur and affect the P45A project's ability to operate at full energy output for certain system conditions. Interpretation of the results is left up to the Interconnection Customer. **The upgrades listed below are not required reliability upgrades for Queue P45A interconnection**. Please note the number of facilities identified below requiring upgrades is quite extensive - with a number of these requiring reconductor/rebuild of transmission lines. Some of the reconductor/rebuild projects can be done in a very "short" time frame while others are quite extensive and will require more time. In general, the time necessary to design and rebuild these facilities would take approximately 2-3 years to complete. If the P45A Interconnection Customer wants to pursue construction of any of these upgrades a separate "Transmission Interconnection" request must be submitted and the upgrades must be performed as merchant transmission projects:

Category A - Transmission System Impacts (Facilities monitored and operated by PJM)

Load flow model used for analysis: Generator Deliverability dispatch with all generators (in-service or active Queue generators preceeding P45A) at 100% energy output and Peak summer loading (80/20 load forecast).

P45A Operational considerations: The facilities below (potentially overloaded) are monitored and operated by PJM. PJM rules and methods for readjusting pre-contingency (N-1) dispatch will be followed if this system condition occurs, this may or may not cause curtailment of P45A generation to below 100% energy output.

1. P45A contributes approximately 17 MW to the contingency overload (109% of the 471 MVA emergency rating) of Keystone 500/230kV transformer #4 for the outage of the Keystone 500/230kV transformer #3 which was originally identified as a potential congestion issue for the Queue P22 project. The upgrade is a replacement of existing 500-230 kV transformer rated at 440 MVA summer normal / 471 MVA summer emergency with a new transformer. It is estimated that this upgrade will cost $5,500,000 and take approximately 2 years to complete.
2. P45A contributes approximately 17 MW to the contingency overload (110% of the 465 MVA emergency rating) of Keystone 500/230kV transformer #3 for the outage of the Keystone 500/230kV transformer #4, which was originally identified as a potential congestion issue for the Queue P22 project. The upgrade is a replacement of existing 500-230 kV transformer rated at 440 MVA summer normal / 471 MVA summer emergency with a new transformer. It is estimated that this upgrade will cost $5,500,000 and take approximately 2 years to complete.
3. P45A contributes approximately 21 MW to the contingency overload of the Homer City - Shelocta 230 kV circuit for the outage of the Handsome Lake to Wayne 345 kV circuit, which was originally identified as a potential congestion issue for the Queue O56 project. The Homer City-Shelocta 230 kV line is rated at 694 MVA summer normal / 854 MVA summer emergency. The loading on this 230 kV line during the contingency condition reaches 914 MVA (or 107% of its rating). To mitigate this overload would require replacement/upgrade of the disconnect switch at Shelocta which is estimated to be approximately $75,000 and the

replacement/upgrade of 10.73 miles of 230 kV transmission line conductor between Homer City and Shelocta – which is estimated to be approximately $8,000,000.

4. P45A contributes 7 MW to the contingency overload of the Lewistown - Juniata 230 kV line for the outage of Juniata to Keystone 500 kV line, which was originally identified as a potential congestion issue for the Queue #O38 project. The Lewistown-Juniata 230 kV line is rated at 499 MVA summer normal / 617 MVA summer emergency. The loading on this 230 kV line during the contingency condition reaches 654 MVA (or 106% of its rating). To mitigate this overload would require replacement/upgrade of 24.69 miles of 230 kV transmission line conductor between Lewistown and Juniata which is estimated to be approximately $11,750,000 and the replacement/upgrade of the disconnect switch at Juniata which is estimated to be approximately $75,000.
5. P45A contributes 7 MW to the contingency overload of the Shelocta – Keystone 230 kV line for the outage of Homer city to WATRC 345 kV line, which was originally identified as a potential congestion issue for the Queue #P28 project. The Shelocta-Keystone 230 kV line is rated at 694 MVA summer normal / 854 MVA summer emergency. The loading on this 230 kV line during the contingency condition reaches 864 MVA (or 101% of its rating). To mitigate this overload would require replacement/upgrade of the disconnect switches at Shelocta and Keystone substations and is estimated to be approximately $150,000.
6. P45A contributes 7 MW to the contingency overload of the Altoona - Raystown 230 kV line for the outage of the Homer-Shelocta-Keystone 230 kV circuit, which was originally identified as a potential congestion issue for the Queue #O72 project. The Altoona-Raystown 230 kV line is rated at 488 MVA summer normal / 554 MVA summer emergency. The loading on this 230 kV line during the contingency condition reaches 582 MVA (or 105% of its rating). To mitigate this overload would require replacement/upgrade of the wave/line trap at Altoona substation and is estimated to be approximately $125,000.
7. P45A contributes 7 MW to the contingency overload of the Lewistown - Raystown 230 kV line for the outage of the Homer City – Shelocta - Keystone 230 kV circuit, which was originally identified as a potential congestion issue for the Queue #O72 project. The Lewistown-Raystown 230 kV line is rated at 488 MVA summer normal / 554 MVA summer emergency. The loading on this 230 kV line during the contingency condition reaches 559 MVA (or 101% of its rating). To mitigate this overload would require replacement/upgrade of the wave trap at Altoona substation and is estimated to be approximately $125,000 and the upgrade of a CT circuit at Altoona and is estimated to be approximately $100,000.

Category B – Underlying Transmission System Impacts (Facilities monitored and operated by Penelec)

Load flow model used for analysis: Generator Deliverability dispatch with all generators (in-service or active Queue generators preceeding P45A) at 100% energy output and Peak summer loading (80/20 load forecast).

P45A Operational considerations: The facilities below (potentially overloaded) are not monitored and operated by PJM. Penelec monitors these facilities real time and will readjust the system according to Penelec's rules and methods if this system condition occurs, this may or may not cause curtailment of P45A generation to below 100% energy output.

8. P45A contributes 0.387 MW to the contingency overload of the Laurel Lake - Goudey 115 kV line for the loss of the East Towanda - Hillside 230 kV and the East Sayre - East Towanda 115 kV line which this project is identified as the originally identified the first project for this potential congestion issue. The Laurel Lake-Goudey 115 kV line is rated at 108 MVA summer normal / 129 MVA summer emergency. The loading on this 115 kV line during the contingency condition reaches 129.4 MVA (or 100.3% of its rating). To mitigate this overload would require replacement/upgrade of the some of substation conductor at Goudey substation and is estimated to be approximately $120,000.

Category C – Underlying Transmission System Impacts (Facilities monitored and operated by Penelec). These contingencies were not possible prior to Queue P45A. The identified contingency overloads are caused directly by P45A and are likely to cause P45A curtailment to less than 100% energy output during summer and possibly winter operation.

Load flow model used for analysis: Generator Deliverability dispatch with all generators (in-service or active Queue generators preceeding P45A) at 100% energy output and Peak summer loading (80/20 load forecast).

P45A Operational considerations: The facilities below (potentially overloaded) are not monitored and operated by PJM. Penelec monitors these facilities real time and will readjust the system according to Penelec's rules and methods if this system condition occurs, this may or may not cause curtailment of P45A generation to below 100% energy output.

9. P45A contributes 96 MW to the contingency overload (513% of the summer emergency rating of 23.4 MVA) of the Thompson 115-34.5 kV transformer for the loss of the Tiffany - P45 115 kV line. The Thompson 115-34.5 kV transformer is rated at 21.8 MVA summer normal / 23.4 MVA summer emergency. The loading on this 115 kV transformer during the contingency condition reaches 120 MVA (or 513% of its emergency rating). To mitigate this overload would require replacement/upgrade of the transformer, circuit breaker and substation conductor and is estimated to be approximately $1,750,00.
10. P45A contributes 9 MW to the overload of the Tiffany-Franklin Forks 34.5 kV line (approx 4.79 miles with a summer emergency rating of 23 MVA) for the loss of the Tiffany-P45 kV line. The Tiffany-Franklin Forks 34.5 kV line is rated at 23 MVA. The loading on this 34.5

kV line during the contingency condition reaches 32 MVA (or 139% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $840,000.

11. P45A contributes 24 MW to the overload of the Franklin Forks-Hallstead 34.5 kV line (approx 6.93 miles with a summer emergency rating of 13 MVA) for the loss of the Tiffany-P45 kV line. The Franklin Forks-Hallstead 34.5 kV line is rated at 13 MVA. The loading on this 34.5 kV line during the contingency condition reaches 37 MVA (or 285% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $1,300,000.
12. P45A contributes 25 MW to the overload of the Hallstead-Great Bend 34.5 kV line (approx 0.21 miles with a summer emergency rating of 13 MVA) for the loss of the Tiffany-P45 kV line. The Hallstead-Great Bend 34.5 kV line is rated at 13 MVA. The loading on this 34.5 kV line during the contingency condition reaches 38 MVA (or 292% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $40,000.
13. P45A contributes 27 MW to the overload of the Great Bend-Great Bend REC 34.5 kV (approx 1.14 miles with a summer emergency rating of 13 MVA) line for the loss of the Tiffany-P45 kV line. The Great Bend-Great Bend REC 34.5 kV line is rated at 13 MVA. The loading on this 34.5 kV line during the contingency condition reaches 40 MVA (or 307% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $200,000.
14. P45A contributes 28 MW to the overload of the Great Bend REC-Chenango Tap 34.5 kV (approx 0.39 miles with a summer emergency rating of 13 MVA) line for the loss of the Tiffany-P45 kV line. The Great Bend REC-Chenango Tap 34.5 kV line is rated at 13 MVA. The loading on this 34.5 kV line during the contingency condition reaches 41 MVA (or 315% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $70,000.
15. P45A contributes 29 MW to the overload of the Chenango Tap-Oakland 34.5 kV (approx 5.35 miles with a summer emergency rating of 13 MVA) line for the loss of the Tiffany-P45 kV line. The Chenango Tap-Oakland 34.5 kV line is rated at 13 MVA. The loading on this 34.5 kV line during the contingency condition reaches 42 MVA (or 323% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $950,000.
16. P45A contributes 22 MW to the overload of the Tiffany-Heart Lake 34.5 kV line (approx 3.94 miles with a summer emergency rating of 15 MVA) for the loss of the Tiffany-P45 kV line. The Tiffany-Heart Lake 34.5 kV line is rated at 15 MVA. The loading on this 34.5 kV line during the contingency condition reaches 37 MVA (or 247% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $700,000.

17. P45A contributes 23 MW to the overload of the Heart Lake-New Milford 34.5 kV line (approx 3.98 miles with a summer emergency rating of 15 MVA) for the loss of the Tiffany-P45 kV line. The Heart Lake-New Milford 34.5 kV line is rated at 15 MVA. The loading on this 34.5 kV line during the contingency condition reaches 38 MVA (or 253% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $700,000.
18. P45A contributes 26 MW to the overload of the New Milford-Canavan 34.5 kV line (approx 6.77 miles with a summer emergency rating of 15 MVA) for the loss of the Tiffany-P45 kV line. The New Milford-Canavan 34.5 kV line is rated at 15 MVA. The loading on this 34.5 kV line during the contingency condition reaches 41 MVA (or 273% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $1,200,000.
19. It contributes 27 MW to the overload of the Canavan-Oakland 34.5 kV line (approx 0.55 miles with a summer emergency rating of 15 MVA) for the loss of the Tiffany-P45 kV line. The Canavan-Oakland 34.5 kV line is rated at 15 MVA. The loading on this 34.5 kV line during the contingency condition reaches 42 MVA (or 280% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $100,000.
20. P45A contributes 55 MW to the overload of the Oakland-YOS Tap 34.5 kV line (approx 0.42 miles with a summer emergency rating of 31 MVA) for the loss of the Tiffany-P45 kV line. The Oakland-YOS Tap 34.5 kV line is rated at 31 MVA. The loading on this 34.5 kV line during the contingency condition reaches 86 MVA (or 277 % of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $80,000.
21. P45A contributes 75 MW to the overload of the YOS Tap-Susquehanna 34.5 kV line (approx 1.23 miles with a summer emergency rating of 11 MVA) for the loss of the Tiffany-P45 kV line. The YOS-Susquehanna 34.5 kV line is rated at 11 MVA. The loading on this 34.5 kV line during the contingency condition reaches 86 MVA (or 277% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $300,000.
22. P45A contributes 77 MW to the overload of the Susquehanna-Starucca 34.5 kV line (approx 6.61 miles with a summer emergency rating of 11 MVA) for the loss of the Tiffany-P45 kV line. The Susquehanna-Starucca 34.5 kV line is rated at 11 MVA. The loading on this 34.5 kV line during the contingency condition reaches 88 MVA (or 800% of its rating). To mitigate this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $1,400,000.
23. P45A contributes 67 MW to the overload of the Starrucca-Thompson 34.5 kV line (approx 0.98 miles with a summer emergency rating of 23 MVA) for the loss of the Tiffany-P45 kV line. The Starucca-Thompson 34.5 kV line is rated at 23 MVA. The loading on this 34.5 kV line during the contingency condition reaches 90 MVA (or 391% of its rating). To mitigate

this overload would require replacement/upgrade of the line (which may include transmission line conductor, poles, insulators, crossarms, etc) and is estimated to be approximately $225,000.

24. P45A contributes 3.7 MW to the overload of the Tiffany 115-34.5 kV transformer #1 for the loss of the Tiffany-P45 115 kV line. The Tiffany 115-34.5 kV transformer #1 is rated at 24.9 MVA summer normal / 26.7 MVA summer emergency. The loading on this 115-34.5 kV transformer during the contingency condition reaches 30.4 MVA (or 114% of its rating). To mitigate this overload would require replacement/upgrade of the transformer with one of a larger size and is estimated to be approximately $1,300,000.
25. P45A contributes 1.6 MW to the overload of the Tiffany 115-34.5 kV transformer #2 for the loss of the Tiffany-P45 115 kV line. The Tiffany 115-34.5 kV transformer #2 is rated at 25.5 MVA summer normal / 28 MVA summer emergency. The loading on this 115-34.5 kV transformer during the contingency condition reaches 29.6 MVA (or 106% of its rating). To mitigate this overload would require replacement/upgrade of the transformer with one of a larger size and is estimated to be approximately $1,300,000.

Option #2 – Lackawanna – East Carbondale 69 kV Interconnection

Network Impacts (Option #2)

The Queue P45A project was studied as a 120 MW injection into the Lackawanna – East Carbondale 69 kV circuit for summer peak conditions in 2011. This project was evaluated as 120 MW (energy), 24 MW (capacity). Potential Network Impacts were as follows:

Generator Deliverability (single contingency)
No problems identified.

Local PPL EU Reliability Criteria
The rebuilt 69 kV circuit between the P45A interconnection substation and the Lackawanna 230/69 kV regional substation will be approximately 28 miles. To compensate for the losses created by the 120 MW flow across this circuit, a 69 kV capacitor bank may be required in the vicinity of the Edella 69/12 kV substation. If sufficient land exists at this substation, the capacitor bank installation will increase the total cost estimate given by approximately $0.5 million dollars.

Load flow analysis shows that a large standing angle exists between the P45A generator bus and the Lackawanna 230/69 kV regional substation when P45A operates at 120 MW. That standing angle causes a significant reactive flow from the Lackawanna substation to the P45A bus. At 60 MW output, the standing angle is reduced significantly.

Because of the above situation, PPL EU asks the Interconnection Customer to reconsider its decision to place 120 MW onto one 69 kV circuit. PPL EU suggests that 69 kV double-circuit be installed between the P45A intertie substation and Lackawanna substation, with a maximum generation output of 60 MW per circuit.

Multiple Facility Contingency (MAAC Criteria IIC)
No problems identified.

Short Circuit Analysis
The three-phase symmetrical short circuit duty at the 69 kV point-of-connection, with P45A generation in-service, is estimated to be approximately 542 MVA. The phase-to-ground symmetrical short circuit duty will be approximately 4361 Amps. No 69 kV or 230 kV breakers at Lackawanna substation were identified as being overdutied. The Waymart/Brownell generation was connected to the Lackawanna-Peckville #1 circuit (new outlet) for these calculations.

Stability Analysis
Will be performed during the Queue P45A Impact Study.

Network Upgrade Requirements
None identified.

Contribution to Previously Identified Upgrade Requirements
None identified.

Docs # 382240